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#### PRIOR ART

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[Description of the Prior Art] The property required of distorted electrical resistance materials has a large resistance value change to \*\* distortion. The ratio of resistance rate-of-change  $\frac{\Delta R}{R}$  to distortion epsilon is called gage-factor  $\frac{\Delta R}{\epsilon R}$ . This determines the sensibility when making a sensor using distorted electrical resistance materials. In order to make the sensor of high sensitivity, the high distorted electrical resistance materials of a gage factor are required. It is because the allowances over a noise will become large and the burden of latter amplifier will be mitigated, if sensibility is high.

[0003] \*\* A temperature resistance coefficient is small. That is, with temperature, I hear that resistance does not change a lot and there is. ( $\frac{\Delta R}{R \Delta T}$ ) can express to \*\*\*\* of being small. This value is called temperature coefficient of resistance (TCR). It is because the resistance change by the temperature change surpasses the resistance change by distortion and it becomes impossible to ask for distortion correctly, when this is large.

\*\* There is little change by the temperature of sensibility. If this is large, it will be said that sensibility changes with temperature and it is not desirable. The temperature coefficient of sensibility is called TCS.

\*\* There is little aging. There is thermal resistance. It is reliable.

\*\*\*\*\*

[0004] The following things are known by distorted strain gage-type electrical resistance materials from the former.

(1) Distorted electrical resistance materials of a metal system like NiCr or CuNi.

(2) Semi-conductors, such as Si.

Like NiCr (Nichrome) and CuNi (advance), since a temperature coefficient of resistance is small and the property is stable, metalead distorted electrical resistance materials are used widely. However, the resistance change to distortion, i.e., sensibility, is low. Gage factors are 2-3 and are low sensibility. Since sensibility is low, the amplifier of a high amplification factor is needed for the latter part. Naturally there are little allowances to a noise.

[0005] The distorted electrical resistance materials of semi-conductors, such as Si, have a gage factor as high as 10-100. It is highly sensitive. And since the advantage in which it can unite with amplifier is on Si substrate by integrated-circuit-izing, it is already used widely. However, since it is a semi-conductor, the resistance change by temperature is very large. That is, since it cannot use if a temperature coefficient of resistance TCR remains as it is greatly, a temperature-compensation circuit is needed. Moreover, it is weak with heat.

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EFFECT OF THE INVENTION

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[Effect of the Invention] Although this invention manufactures the thin film distorted resistance element which makes Cr and O a subject by sputtering or vacuum evaporation, it can manufacture a distorted resistance element with 20 or more gage factors, TCR 50 ppm [ /degree C / or less ], and TCS 500 ppm [ /degree C ] or less by making temperature of a substrate into 150 degrees C or more, and annealing above 400 degrees C after thin film formation. A gage factor is higher than the conventional thin film distorted electrical resistance materials. The stability over temperature is farther [ than the distorted electrical resistance materials of a semi-conductor ] excellent. It excels also in thermal resistance and a reliable distorted resistance element can be obtained.

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**TECHNICAL PROBLEM**


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[Problem(s) to be Solved by the Invention] In recent years, the thin film distorted electrical resistance materials which make Cr a subject are developed as distorted electrical resistance materials of a metal system. Cr is because it is large compared with a common metal, the resistance rate of change, i.e., the gage factor, to distortion. JP,61-256233,A has proposed the sensor which formed Cr or Cr alloy by sputtering on diaphragm or an insulator layer. About the thing using Cr [0007] It is having obtained the engine performance of gage-factor =  $16-17\text{TCR} = -500-600\text{ppm/degree-CTCS} = -500-600\text{ppm/degree C}$ . Moreover, it is written that engine performance which calls the alloy of Cr and Mo gage-factor =  $13-15\text{TCR} = 200-0\text{ppm/degree-CTCS} = -4000-3000\text{ppm/degree C}$  as a thin film by the spatter was obtained.

[0008] JP,2-76201,A has proposed Cr of 60 - 98 atom %, the oxygen of 2 - 30 atom %, and the thin film distorted electrical resistance materials containing Si, germanium, and B of 0 - 10 atom %. It is said that this has the gage-factor =  $5-10\text{TCR} = -73-+75\text{ppm/degree C}$  engine performance. [0009] JP,2-152201,A has proposed Cr of 60 - 98 atom %, the oxygen of 2 - 30 atom %, and the thin film distorted electrical resistance materials containing aluminum, Ti, and Ta of 0 - 10 atom %. There is also this having demonstrated the gage-factor =  $5-10\text{TCR} = -83-+75\text{ppm/degree C}$  property.

[0010] Thus, although various distorted electrical resistance materials which made the subject the distorted electrical resistance materials which made Cr the subject, and Cr and oxygen are proposed, they are not satisfied with coincidence of the demand about gage factors, and all TCR (s) and TCSes. Moreover, in dependability, such as thermal resistance and distortion endurance, it was not enough.

[0011] This invention makes Cr and oxygen a subject and aims at offering distorted electrical resistance materials with a large gage factor, and low TCR and TCS. Cr of bulk has a high gage factor (gage-factor \*\*30). However, the opposite side TCR is very large. It is  $\text{TCR}^{**} + 3000\text{ppm/degree C}$ . In order to maintain a high gage factor and to lower TCR, what to carry out what or this is a problem. Since electrons are scattered about and a mean free path becomes short with an impurity, putting an impurity into Cr as mentioned above uses the property in which a temperature coefficient of resistance TCR falls. However, generally a gage factor also falls to coincidence. In the distorted electrical resistance materials which make conventional Cr and O a subject, that in which the compound of Cr and O existed in the amorphous condition is conjectured. Only in the part, metal Cr decreases. It is thought that reduction of Metal Cr is reducing the gage factor.

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MEANS

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[Means for Solving the Problem] The thin film distorted electrical resistance materials of this invention make Cr and O a subject, and are Cr of a body center cube (bcc), and trigonal Cr<sub>2</sub>O<sub>3</sub>. It is characterized by having the crystal structure. In order to manufacture this, the film which makes substrate temperature 150 degrees C or more, and makes Cr and O a subject by vacuum evaporation or sputtering is formed, and it heat-treats at the temperature of 400 degrees C or more. When it carries out like this, the oxide of amorphous-like Cr is Cr<sub>2</sub>O<sub>3</sub>. It changes and is trigonal Cr<sub>2</sub>O<sub>3</sub> as a result. It becomes the structure of bccCr. bccCr maintains a prevention gage factor for resistance highly low. Trigonal Cr<sub>2</sub>O<sub>3</sub> I shortened the electronic mean free path and think that there is an operation which lowers a temperature coefficient of resistance TCR.

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DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]

[Drawing 1] The sectional view of the distortion sensor using thin film distorted electrical resistance materials.

[Description of Notations]

- 1 Stainless Steel Diaphragm
- 2 Insulator Layer
- 3 Distorted Resistance Film
- 4 Multilayer Electrode
- 5 Ti
- 6 Ni
- 7 Au

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## DETAILED DESCRIPTION

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### [Detailed Description of the Invention]

[0001]

[Industrial Application] This invention relates to the distorted strain gage-type electrical resistance materials for measuring a pressure, the force, distortion, acceleration, a flow rate, etc. as a resistance value change by distortion of a metal thin film, that manufacture approach, the sensor using this, etc. Distorted electrical resistance materials say the thing of the ingredient from which resistance changes by being distorted. If distorted electrical resistance materials are attached in diaphragm, since diaphragm will deform with a pressure, the resistance of distorted electrical resistance materials changes. A pressure can be measured by the resistance value change. Moreover, if distorted electrical resistance materials are stuck on the metaled bar, since a rod will bend in proportion to the force applied to the rod, distorted electrical resistance materials expand and contract. Since resistance changes with these, the magnitude of the force can be measured.

[0002]

[Description of the Prior Art] The property required of distorted electrical resistance materials has a large resistance value change to \*\* distortion. The ratio of resistance rate-of-change  $\frac{\Delta R}{R}$  to distortion  $\epsilon$  is called gage-factor  $\frac{\Delta R}{R \epsilon}$ . This determines the sensibility when making a sensor using distorted electrical resistance materials. In order to make the sensor of high sensitivity, the high distorted electrical resistance materials of a gage factor are required. It is because the allowances over a noise will become large and the burden of latter amplifier will be mitigated, if sensibility is high.

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Like NiCr (Nichrome) and CuNi (advance), since a temperature coefficient of resistance is small and the property is stable, metaled distorted electrical resistance materials are used widely. However, the resistance change to distortion, i.e., sensibility, is low. Gage factors are 2-3 and are low sensibility. Since sensibility is low, the amplifier of a high amplification factor is needed for the latter part. Naturally there are little allowances to a noise.

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is a semi-conductor, the resistance change by temperature is very large. That is, since it cannot use if a temperature coefficient of resistance TCR remains as it is greatly, a temperature-compensation circuit is needed. Moreover, it is weak with heat.

[0006]

[Problem(s) to be Solved by the Invention] In recent years, the thin film distorted electrical resistance materials which make Cr a subject are developed as distorted electrical resistance materials of a metal system. Cr is because it is large compared with a common metal, the resistance rate of change, i.e., the gage factor, to distortion. JP,61-256233,A has proposed the sensor which formed Cr or Cr alloy by sputtering on diaphragm or an insulator layer. About the thing using Cr, it is [0007]. It is having obtained the engine performance of gage-factor =16-17TCR=500-600ppm/degree-CTCS=500-600ppm/degree C. Moreover, it is written that engine performance which calls the alloy of Cr and Mo gage-factor =13-15TCR=-200-0ppm/degree-CTCS=-4000--3000ppm/degree C as a thin film by the spatter was obtained.

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[0010] Thus, although various distorted electrical resistance materials which made the subject the distorted electrical resistance materials which made Cr the subject, and Cr and oxygen are proposed, they are not satisfied with coincidence of the demand about gage factors, and all TCR (s) and TCSes. Moreover, in dependability, such as thermal resistance and distortion endurance, it was not enough.

[0011] This invention makes Cr and oxygen a subject and aims at offering distorted electrical resistance materials with a large gage factor, and low TCR and TCS. Cr of bulk has a high gage factor (gage-factor \*\*30). However, the opposite side TCR is very large. It is TCR\*\*+3000ppm/degree C. In order to maintain a high gage factor and to lower TCR, what to carry out what or this is a problem. Since electrons are scattered about and a mean free path becomes short with an impurity, putting an impurity into Cr as mentioned above uses the property in which a temperature coefficient of resistance TCR falls. However, generally a gage factor also falls to coincidence. In the distorted electrical resistance materials which make conventional Cr and O a subject, that in which the compound of Cr and O existed in the amorphous condition is conjectured. Only in the part, metaled Cr decreases. It is thought that reduction of Metal Cr is reducing the gage factor.

[0012]

[Means for Solving the Problem] The thin film distorted electrical resistance materials of this invention make Cr and O a subject, and are Cr of a body center cube (bcc), and trigonal Cr<sub>2</sub>O<sub>3</sub>. It is characterized by having the crystal structure. In order to manufacture this, the film which makes substrate temperature 150 degrees C or more, and makes Cr and O a subject by vacuum evaporation or sputtering is formed, and it heat-treats at the temperature of 400 degrees C or more. When it carries out like this, the oxide of amorphous-like Cr is Cr<sub>2</sub>O<sub>3</sub>. It changes and is trigonal Cr<sub>2</sub>O<sub>3</sub> as a result. It becomes the structure of bccCr. bccCr maintains a prevention gage factor for resistance highly low. Trigonal Cr<sub>2</sub>O<sub>3</sub> I shortened the electronic mean free path and think that there is an operation which lowers a temperature coefficient of resistance TCR.

[0013]

[Function] In case a thin film Cr is made first, it explains why it becomes a compound with oxygen. Usually, vacuum deposition and sputtering are used for thin film formation of Cr. In these thin film deposition systems, there is an upper limit in a ultimate vacuum from structures, such as evacuation equipment, and piping, a chamber. 10<sup>-7</sup> - 10<sup>-5</sup>Torr are the highest generally. It cannot lengthen to the degree of vacuum beyond this. Many oxygen, steams, etc. are contained in residual gas. Since Cr is heated, and vacuum deposition or sputtering also evaporates it or is flown as a

small molecule lump, oxygen will be incorporated in this. Since oxygen is an element especially with strong activity, it cannot prevent mixing of the oxygen to a thin film in the degree of vacuum of above-mentioned extent. Residual oxygen surely mixes in the thin film Cr created by vacuum evaporation and the sputter. Although the amount of the oxygen in Cr changes with distance from a ultimate vacuum, the pressure at the time of film formation, the film rate of sedimentation, and an evaporation source to a substrate etc., it is usually pentatomic % - 20 atom %. This stops, there is and it is contained. [ no ] It is difficult to make the thin film Cr which does not contain oxygen.

[0014] It can also be said that it furthermore progresses and makes more oxygen mix positively. It is made by introducing oxygen as an ambient atmosphere of a vacuum evaporation system. Moreover, it can also be said that the oxygen else [ , such as an argon, ] is introduced into a sputtering system, and mixing to Cr of oxygen is promoted.

[0015] In the usual condition, O in Cr is CrOx. It is in an amorphous condition. CrOx of an amorphous condition The dispersion lead in electronic is taken and an electronic mean free path is shortened. Since a mean free path becomes short, there is work which lowers a temperature coefficient of resistance TCR and the temperature coefficient TCS of sensibility. However, amorphous CrOx And CrOx Generally the distorted electrical resistance materials of included Cr thin film will become what has a low gage factor. Moreover, amorphous CrOx It is the unstable matter, and in order that a presentation and structure may tend to change with heat, properties, such as thermal resistance, a mechanical strength, and distortion endurance, deteriorate. For this reason, the dependability as a strain gage will be reduced greatly.

[0016] then, amorphous CrOx unstable in this invention Stable Cr 2O3 it changes -- making -- metals Cr [ Cr and ] 2O3 from -- by considering as the becoming microcrystal structure, a gage factor tends to be secured with Metal Cr and it is going to measure reduction of TCR with microcrystal structure. Moreover, Cr and Cr 2O3 Since microcrystal structure is stable, the improvement in dependability of a heatproof, distortion endurance, etc. can also measure it to coincidence.

[0017] Then, it is amorphous CrOx how. It loses and is Cr 2O3 of stable polycrystal. As to it is generable, it is holding the temperature of a substrate at 150 degrees C or more in vacuum evaporation and a sputter first. And after a thin film is made, it heat-treats at the temperature of 400 degrees C or more. It is amorphous CrOx if it does in this way. Cr 2O3 It changes. If the temperature of a substrate is low, since it will quench the steam of Cr with a substrate, it becomes amorphous. Since Cr will be annealed in a substrate if a substrate is maintained at an elevated temperature, it crystallizes. Heat treatment after production is residual amorphous CrOx. It is effective in the semantics which promotes polycrystal-ization further. Since energy is given by heat treatment, a structural change starts and the partial phase transition to the polycrystal condition that free energy is more low may happen. The Cr+O system of this invention becomes the trigonal Cr2 O3+ metal Cr with heating at the time of such thin film formation, and heating after generation.

[0018] The distorted electrical resistance materials of this invention are made from such a process, and have the following outstanding properties.

[property of this invention distorted electrical resistance materials] gage-factor >20TCR<50 ppm /degree C ] TCS -- < -- this invention sets \*\*500 ppm /further degree C, and even if it mixes other metals below pentatomic %, it does not interfere. However, generally metaled addition reduces a gage factor. So, if metaled addition exceeds pentatomic %, it becomes [ a gage factor ] 20 or less and is not desirable.

[0019]

[Example] It is SiO2 with a thickness of 6 micrometers by the sputtering method on a stainless steel diaphragm substrate with a thickness of 0.2mm. The insulator layer was formed. Furthermore, the distorted resistance film of 0.2-micrometer thickness which makes Cr and O a subject was formed by the vacuum deposition method and the sputtering method on it. Vacuum deposition and the conditions of sputtering are as being shown in Table 1.

[0020]

[Table 1]

表1 真空蒸着法、スパッタリング法による歪抵抗材料の形成条件

	真空蒸着	スパッタリング
到達真空度	$10^{-5} \sim 10^{-7}$ Torr	$10^{-6} \sim 10^{-7}$ Torr
膜形成時の圧力	$10^{-6} \sim 10^{-8}$ Torr	$10^{-1} \sim 10^{-2}$ Torr
膜形成時の基板温度	200℃	150℃
膜形成速度	5 Å/sec	7 Å/sec

[0021] In the case of vacuum deposition, it lengthens to  $10^{-5}$  -  $10^{-7}$ Torr at first, and vacuum evaporation is started after heating a substrate at 200 degrees C. a film formation rate -- 5Å/sec it is. The pressures at the time of film formation were  $10^{-5}$  -  $10^{-6}$ Torr. In the case of sputtering, it lengthened to  $10^{-6}$  -  $10^{-7}$ Torr at first, it ionized argon gas in the plasma by the RF, and formed membranes by the RF sputtering method which strikes Cr target. The pressures at the time of film formation were  $10^{-1}$  -  $10^{-2}$ Torr. Substrate temperature is 150 degrees C or 200 degrees C. Substrate temperature is important. By the approach of this invention, substrate temperature must be 150 degrees C or more. Both may be replaced, although it considers as 200 degrees C in vacuum deposition and being considered as 150 degrees C by sputtering here. Of course, an elevated temperature is more sufficient.

[0022] The formation conditions for every sample, the conditions of heat treatment after formation, and the crystal structure analyzed with the thin film X-ray diffraction method are shown in Table 2.

[0023]

[Table 2]

表2 Crを含む歪抵抗材料の製造条件と結晶構造

試料番号	組成	製法区分	基板温度 (℃)	アニール雰囲気	アニール温度 (℃)	結晶構造 (薄膜X線回折法による解析結果)
1	Cr/7%O	真空蒸着	200	大気	400	bccCr+Cr <sub>2</sub> O <sub>3</sub>
2	Cr/13%O	スパッタ	150	大気	450	bccCr+Cr <sub>2</sub> O <sub>3</sub>
3	Cr/15%O	スパッタ	200	窒素	500	bccCr+Cr <sub>2</sub> O <sub>3</sub>
4	Cr/17%O	スパッタ	150	窒素	450	bccCr+Cr <sub>2</sub> O <sub>3</sub>
5	Cr/3%Mo/12%O	スパッタ	150	大気	500	bccCr+Cr <sub>2</sub> O <sub>3</sub>
6	Cr/1%Mo/7%O	真空蒸着	200	大気	500	bccCr+Cr <sub>2</sub> O <sub>3</sub>
7	Cr/2%Si/5%O	真空蒸着	200	大気	500	bccCr+Cr <sub>2</sub> O <sub>3</sub>
8	Cr/1%Si/12%O	スパッタ	150	大気	450	bccCr+Cr <sub>2</sub> O <sub>3</sub>
9	Cr/4%Al/15%O	スパッタ	150	大気	400	bccCr+Cr <sub>2</sub> O <sub>3</sub>
10	Cr/1%Al/9%O	真空蒸着	200	大気	450	bccCr+Cr <sub>2</sub> O <sub>3</sub>
11	Cr/21%O	スパッタ	常温	なし	なし	アモルファス
12	Cr/12%O	スパッタ	常温	大気	300	bccCrのみ
13	Cr/15%O	スパッタ	常温	大気	500	bccCrのみ

例	組成	形成法	形成温度	雰囲気	焼成温度	焼成後の組織
14	Cr/12%O	スパッタ	200	なし	なし	bccCr のみ
15	Cr/3%Mo/12%O	スパッタ	常温	大気	300	bccCr のみ
16	Cr/4%Si/15%O	スパッタ	常温	大気	300	bccCr のみ
17	Cr/1%Si/9%O	真空蒸着	常温	大気	500	bccCr のみ
18	Cr/4%Al/17%O	スパッタ	常温	大気	300	bccCr のみ
19	Cr/3%Al/8%O	真空蒸着	常温	大気	500	bccCr のみ
20	Cr/10%Mo/12%O	スパッタ	200	なし	なし	bccCr のみ
21	Cr/10%Si/17%O	スパッタ	200	なし	なし	bccCr のみ
22	Cr/10%Mo/12%O	スパッタ	常温	なし	なし	アモルファス
23	Cr/10%Si/17%O	スパッタ	常温	なし	なし	アモルファス

1～10実施例、11～23比較例

[0024] In order to confirm the effectiveness of this invention, the example of a comparison from which the formation and the heat treatment conditions other than an example differ is also manufactured and examined. The example of a comparison raised here forms the distorted resistance film by the approach indicated by aforementioned JP,61-256233,A, JP,2-76201,A, and JP,2-152201,A. 1-10 are the examples of this invention. 11-23 are the examples of a comparison. These distorted resistance film was annealed by the inside of atmospheric air, or nitrogen-gas-atmosphere mind, as shown in Table 2. About the example, it has annealed at the temperature of 400 degrees C or more. Many things were tried [ although annealing is carried out when not carrying out annealing about the example of a comparison, ] when it was 400 degrees C or less, and annealing was carried out above 400 degrees C.

[0025] Then, the crystal structure was analyzed with the thin film X-ray diffraction method, and the component analysis was further carried out by ESCA. The distorted resistance film concerning an example is bccCr and trigonal Cr<sub>2</sub>O<sub>3</sub>. It was mixture. the example of a comparison consists of Cr and O by the sample 11 with the high concentration of O, and samples 22 and 23 -- perfect -- it is amorphous. The example of a comparison with O concentration lower than it is bccCr and amorphous CrOx. It was mixture. At the example of a comparison, it is amorphous CrOx altogether. It contains. This cannot employ the high gage factor of Cr in accumulating efficiently effectively, but has become a low gage factor.

[0026] In the case of this invention, substrate temperature is made into 150 degrees C or more at the time of formation of the distorted resistance film, and it becomes conditions to anneal above 400 degrees C after formation. An example 1 contains 7% of O other than Cr which is a subject. This is formed with vacuum deposition at the substrate temperature of 200 degrees C. It has annealed at 200 degrees C in atmospheric air. This is bccCr and trigonal Cr<sub>2</sub>O<sub>3</sub>. It was mixture.

[0027] An example 2 contains 13% of O. As for this, substrate temperature is formed of sputtering at 150 degrees C. It has annealed at 450 degrees C in atmospheric air after that. This is also bccCr and trigonal Cr<sub>2</sub>O<sub>3</sub>. It is mixture. An example 3 contains 15% of O. Sputtering is carried out at the substrate temperature of 200 degrees C. It has annealed by 500-degree C nitrogen-gas-atmosphere mind after that. bccCr and trigonal Cr<sub>2</sub>O<sub>3</sub> It becomes.

[0028] An example 4 contains 17% of O. Sputtering is carried out at the substrate temperature of 150 degrees C. It annealed in nitrogen-gas-atmosphere mind at 450 degrees C. This also serves as bccCr from trigonal Cr<sub>2</sub>O<sub>3</sub>. An example 5 contains Mo3% other than 12% of O as the 3rd element. Sputtering is carried out at the substrate temperature of 150 degrees C. It annealed at 500 degrees C among atmospheric air. This is also bccCr and trigonal Cr<sub>2</sub>O<sub>3</sub>. It becomes.

[0029] An example 6 contains 7% of O and 1% of Mo. Vacuum deposition is carried out at the

substrate temperature of 200 degrees C. It annealed at 500 degrees C among atmospheric air after that. This is also bccCr and trigonal Cr<sub>2</sub>O<sub>3</sub>. It becomes.

[0030] Vacuum deposition of the example 7 is carried out at . substrate temperature containing 5% of O and 2% of Si of 200 degrees C. It annealed at 500 degrees C among atmospheric air. method \*\* Cr<sub>2</sub>O<sub>3</sub> of bccCr+3 it is . An example 8 contains 12% of O and 1% of Si. Sputtering is carried out at the substrate temperature of 150 degrees C. It annealed at 450 degrees C among atmospheric air behind. method \*\* Cr<sub>2</sub>O<sub>3</sub> of bccCr+3 it is .

[0031] An example 9 contains 15% of O and 4% of aluminum. Sputtering is carried out at the substrate temperature of 150 degrees C. It annealed at 400 degrees C among atmospheric air. method \*\* Cr<sub>2</sub>O<sub>3</sub> of bccCr+3 it is . An example 10 contains 9% of O and 1% of aluminum. Vacuum deposition is carried out at the substrate temperature of 200 degrees C. It annealed at 450 degrees C among atmospheric air. It is method \*\* Cr<sub>2</sub>O<sub>3</sub> of bccCr+3.

[0032] Sputtering of the example 11 of a comparison is carried out in ordinary temperature, and it has not carried out annealing again. For this reason, amorphous CrOx in which bccCr is not generated and structure does not become settled It has become. Sputtering of the example 12 of a comparison is carried out in ordinary temperature. It has annealed at 300 degrees C after formation. The remainder is amorphous CrOx although bccCr is formed. It has become. Sputtering also of the example 13 of a comparison is carried out in ordinary temperature. Although annealed at 500 degrees C after that, they are bccCr and amorphous CrOx. It is a mixture.

[0033] The example 14 of a comparison is carrying out and carrying out sputtering of the substrate temperature to 200 degrees C. However, this has not annealed. It is amorphous CrOx too. It remains. As for the examples 15-23 of a comparison, oxygen and elements other than Cr are contained. The examples 15, 20, and 22 of a comparison contain Mo as the 3rd element. The examples 16, 17, 21, and 23 of a comparison contain Si. The examples 18 and 19 of a comparison contain aluminum. If these 3rd metal is included, a gage factor will fall, but shortly after a metal is included, it is not said that it is bad. The examples 5 and 6 of this invention contain Mo. Examples 7 and 8 contain Si. Examples 9 and 10 contain aluminum. Such conditions are the same.

However, as for the examples 15-19 of a comparison, other conditions differ from this invention.

[0034] Since substrate temperature is ordinary temperature, the examples 15-19 of a comparison are not applied to the conditions of 150 degrees C or more of this invention. These are amorphous CrOx besides bccCr, although annealing is carried out at the temperature of 300-500 degrees C. It only exists. Trigonal Cr<sub>2</sub>O<sub>3</sub> It is not formed. It is because the substrate temperature at the time of formation was low. The example 20 of a comparison contains 10% of Mo. Sputtering of this is carried out at the substrate temperature of 200 degrees C. However, annealing has not been carried out. It is amorphous CrOx too. It is the mixture of bccCr.

[0035] The example 21 of a comparison contains 10% of Si. At the substrate temperature of 200 degrees C, sputtering is carried out and it forms. Annealing has not been carried out. This is also the mixture of bccCr and amorphous CrOx. The example 22 of a comparison contains 10% of Mo. Sputtering of the substrate is carried out without heating. Moreover, annealing is not carried out. Since it quenches Cr with a substrate, the whole is amorphous CrOx. It becomes.

[0036] The example 23 of a comparison contains 10% of Si. The substrate is not heated. Annealing after formation has not been carried out, either. This is also amorphous CrOx. It has become. If sputtering of the Cr is carried out without heating a substrate from these examples of a comparison, on a substrate, it is amorphous CrOx. Since it is formed and annealing is made behind, bccCr is amorphous CrOx. It is formed in inside and it turns out that it grows up and goes. However, it is amorphous CrOx even if it carries out annealing after formation. It eliminates completely and it turns out that it cannot be made the polycrystal of Cr and oxygen.

[0037] With the vacuum deposition method, the multilayer electrode of Ti/nickel/Au was formed in these distorted resistance film one by one. This is an ohmic contact electrode. The structure of this component is shown in drawing 1 . An insulator layer (SiO<sub>2</sub>) 2 is formed on the diaphragm 1 of stainless steel, and there is the distorted resistance film 3 on it further. The multilayer electrode 4 can be formed in the edge of the distorted resistance film 3, and can pass a current now.

Resistance-after gage-factor, temperature-coefficient-of-resistance TCR, sensibility temperature coefficient TCS, thermal-resistance (\*\*, \*\*, \*\*), and distorted durability change was measured about these samples 1-23. Thermal resistance is carrying out the following three measurement. This was shown in Table 3.

[0038]

[Table 3]

表3 各試料の歪抵抗膜の特性

試料 番号	ゲージ率	TCR 抵抗温度 係数 (ppm/℃)	TCS 感度温度 係数 (ppm/℃)	高温放 置抵抗 変化 (%)	ヒート サイクル 抵抗 変化 (%)	サーマ ルショ ック抵 抗変化 (%)	歪耐久 後抵抗 変化 (%)
1	21.1	35	-450	-0.6%	<-0.5%	<+0.5%	<-0.5%
2	20.5	-20	330	<+0.5%	<+0.5%	-0.7%	<-0.5%
3	25.3	25	500	<+0.5%	<-0.5%	<-0.5%	+0.7%
4	23.6	-30	-490	+0.6%	<+0.5%	+0.6%	<+0.5%
5	20.0	-47	-480	<+0.5%	-0.7%	-0.5%	<+0.5%
6	21.2	9	-150	<-0.5%	-0.5%	+0.7%	+0.6%
7	20.4	49	-500	<+0.5%	-0.6%	<-0.5%	+0.7%
8	21.0	-35	380	+0.7%	<+0.5%	+0.8%	-0.5%
9	20.3	-20	-350	+0.6%	+0.7%	-0.5%	<-0.5%
10	21.1	28	400	+0.5%	<-0.5%	-0.6%	+0.7%
11	3.0	-15	-520	-35.0%	-27.7%	-21.5%	+7.0%
12	14.5	-650	-2000	-5.2%	+3.7%	+4.0%	+3.7%
13	12.8	-520	-1500	+1.1%	<+0.5%	+2.4%	+5.1%
14	10.3	-730	-1800	+3.5%	-4.3%	-2.7%	+2.2%
15	15.0	-250	-3200	+4.0%	-1.5%	+3.5%	+4.5%
16	9.5	-90	900	-6.6%	-4.7%	-2.6%	+5.0%
17	9.9	88	560	+0.7%	+1.3%	+2.2%	+5.7%
18	6.3	-75	830	-3.5%	+3.9%	-3.3%	+3.0%
19	7.2	95	550	<-0.5%	-1.6%	+1.0%	+4.4%
20	6.0	-180	-1500	+6.3%	-3.8%	-2.8%	+2.0%
21	5.2	-170	-1000	+3.2%	-4.1%	-3.5%	+4.3%
22	4.3	-22	-630	-27 %	-25 %	-22 %	+8.0%
23	3.2	-25	-290	-32 %	-28 %	-29 %	+6.5%

1～10実施例、11～23比較例

[0039]

Resistance change is measured after heating by the approach of each thermal shock of -50 degree-

C-+120 degree-Cx1000 cycle in the thermo-cycle heat resistance test \*\* liquid phase of -40 degree-C-+150 degree-Cx1000 cycle in the elevated-temperature neglect heat resistance test \*\* gaseous phase of heat resistance test \*\* +300-degree-Cx 1000 hours. Of course, the direction with little resistance change is good. I hear that that there is little resistance change has high thermal resistance, and there is.

[0040] Resistance-after distorted durability change is distortion of \*\*2000micro strain 107 It is the thing of the rate of a resistance value change after a \*\*\*\* beam distorted torture test. Also as for this, the smaller one is good. In the example of this invention, 20 or more have all been the gage factor which is an important multiplier. This is what should be mentioned especially. It is difficult to obtain such a high gage factor with metaled thin film distorted electrical resistance materials.

[0041] Moreover, a temperature coefficient of resistance TCR is also 50 ppm/degree C or less in an absolute value, and it turns out that change of resistance by the temperature change is small. The sensibility temperature coefficient TCS is 500 ppm/degree C or less in an absolute value. Thus, this invention can offer the distorted electrical resistance materials which have a high gage factor, low TCR, and TCS. When it anneals at the temperature of 450 degrees C or more especially by the non-oxidizing atmosphere, as for a gage factor, 23 or more things are obtained so that it may see in the examples 3 and 4. They are the distorted electrical resistance materials which were small excellent also-in TCR and TCS.

[0042] The ingredient of this invention also has little resistance change after elevated-temperature neglect. It is 0.7% or less in an absolute value. There is also little thermo-cycle resistance change and it is 0.7% or less in an absolute value. . also with the small resistance change after a thermal shock -- this is 0.8% or less. These show that the distorted electrical resistance materials of this invention are excellent in thermal resistance. Moreover, the resistance change after distortion durability is also very small. This is also 0.7% or less. Although it is repeatedly distorted since it is a strain gage, this invention can offer a component with the high dependability from which resistance hardly changes by distortion.

[0043] The substrate heating temperature at the time of thin film formation is 150 degrees C or more. The temperature of annealing after thin film formation is 400 degrees C or more. These give the minimum of heating. The upper limit of heating is based on the property of a substrate. It must heat-treat at the temperature of extent which does not degrade a substrate. For example, it is SiO<sub>2</sub> on SUS631. If it is the substrate in which the insulator layer was formed, as for the heating temperature at the time of thin film formation, and the heating temperature at the time of annealing, it is desirable that it is 600 degrees C or less. A little metal can also be added in this invention. Although examples 5-10 add Mo, Si, aluminum, etc., these also have 20 or more gage factors. However, since a gage factor will fall if a metaled ratio exceeds 5%, it is not desirable. This becomes clear by comparing 12-14, and the example 20 of a comparison - 23 grades of the example of a comparison.

[0044] The gage factor of what was mentioned as an example of a comparison to these is 15 or less. The examples 15, 12, and 13 of a comparison and 14 grades have a comparatively large gage factor. However, these are inferior to thermal resistance and TCR and TCS are large. In an absolute value, TCR of these examples of a comparison is 250-730 ppm/degree C, and is [ / of / of this invention / 50 ppm/degree C or less ] remarkably inferior. Moreover, in the examples 12-15 of these comparisons, TCS is also 520-3200 ppm/degree C, and is inferior with an absolute value compared with the value of less than 500 ppm/degree C of this invention. Although the examples 11, 17-19 of a comparison, and 22 and 23 have TCR and a little small TCS, since the gage factor is low, sensibility is less than the thing of this invention too bad.

[0045] That is, in the example of a comparison, if it is going to stop [ degree C ] TCR in 100 ppm /or less, a gage factor will become less than ten. If it is going to make a gage factor or more into ten, TCR will exceed degree C in 250 ppm /. Moreover, it is difficult to carry out [ degree C ] TCS in 500 ppm /or less in the example of a comparison. Thus, the example of a comparison cannot satisfy the demand imposed on distorted electrical resistance materials about gage factors, and all TCR(s) and TCSes.

[0046]

[Effect of the Invention] Although this invention manufactures the thin film distorted resistance element which makes Cr and O a subject by sputtering or vacuum evaporation, it can manufacture a distorted resistance element with 20 or more gage factors, TCR 50 ppm [ /degree C / or less ], and TCS 500 ppm [ /degree C ] or less by making temperature of a substrate into 150 degrees C or more, and annealing above 400 degrees C after thin film formation. A gage factor is higher than the conventional thin film distorted electrical resistance materials. The stability over temperature is farther [ than the distorted electrical resistance materials of a semi-conductor ] excellent. It excels also in thermal resistance and a reliable distorted resistance element can be obtained.

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[Translation done.]

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TECHNICAL FIELD

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[Industrial Application] This invention relates to the distorted strain gage-type electrical resistance materials for measuring a pressure, the force, distortion, acceleration, a flow rate, etc. as a resistance value change by distortion of a metal thin film, that manufacture approach, the sensor using this, etc. Distorted electrical resistance materials say the thing of the ingredient from which resistance changes by being distorted. If distorted electrical resistance materials are attached in diaphragm, since diaphragm will deform with a pressure, the resistance of distorted electrical resistance materials changes. A pressure can be measured by the resistance value change. Moreover, if distorted electrical resistance materials are stuck on the metal bar, since a rod will bend in proportion to the force applied to the rod, distorted electrical resistance materials expand and contract. Since resistance changes with these, the magnitude of the force can be measured.

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## OPERATION

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[Function] In case a thin film Cr is made first, it explains why it becomes a compound with oxygen. Usually, vacuum deposition and sputtering are used for thin film formation of Cr. In these thin film deposition systems, there is an upper limit in a ultimate vacuum from structures, such as evacuation equipment, and piping, a chamber.  $10^{-7}$  -  $10^{-5}$  Torr are the highest generally. It cannot lengthen to the degree of vacuum beyond this. Many oxygen, steams, etc. are contained in residual gas. Since Cr is heated, and vacuum deposition or sputtering also evaporates it or is flown as a small molecule lump, oxygen will be incorporated in this. Since oxygen is an element especially with strong activity, it cannot prevent mixing of the oxygen to a thin film in the degree of vacuum of above-mentioned extent. Residual oxygen surely mixes in the thin film Cr created by vacuum evaporation and the spatter. Although the amount of the oxygen in Cr changes with distance from a ultimate vacuum, the pressure at the time of film formation, the film rate of sedimentation, and an evaporation source to a substrate etc., it is usually pentatomic % - 20 atom %. This stops, there is and it is contained. [ no ] It is difficult to make the thin film Cr which does not contain oxygen.

[0014] It can also be said that it furthermore progresses and makes more oxygen mix positively. It is made by introducing oxygen as an ambient atmosphere of a vacuum evaporation system. Moreover, it can also be said that the oxygen else [ such as an argon, ] is introduced into a sputtering system, and mixing to Cr of oxygen is promoted.

[0015] In the usual condition, O in Cr is CrOx. It is in an amorphous condition. CrOx of an amorphous condition The dispersion lead in electronic is taken and an electronic mean free path is shortened. Since a mean free path becomes short, there is work which lowers a temperature coefficient of resistance TCR and the temperature coefficient TCS of sensibility. However, amorphous CrOx And CrOx Generally the distorted electrical resistance materials of included Cr thin film will become what has a low gage factor. Moreover, amorphous CrOx It is the unstable matter, and in order that a presentation and structure may tend to change with heat, properties, such as thermal resistance, a mechanical strength, and distortion endurance, deteriorate. For this reason, the dependability as a strain gage will be reduced greatly.

[0016] then, amorphous CrOx unstable in this invention Stable Cr 2O3 it changes -- making -- metals Cr [ Cr and ] 2O3 from -- by considering as the becoming microcrystal structure, a gage factor tends to be secured with Metal Cr and it is going to measure reduction of TCR with microcrystal structure. Moreover, Cr and Cr 2O3 Since microcrystal structure is stable, the improvement in dependability of a heatproof, distortion endurance, etc. can also measure it to coincidence.

[0017] Then, it is amorphous CrOx how. It loses and is Cr 2O3 of stable polycrystal. As to it is generable, it is holding the temperature of a substrate at 150 degrees C or more in vacuum evaporation and a spatter first. And after a thin film is made, it heat-treats at the temperature of 400 degrees C or more. It is amorphous CrOx if it does in this way. Cr 2O3 It changes. If the temperature of a substrate is low, since it will quench the steam of Cr with a substrate, it becomes amorphous. Since Cr will be annealed in a substrate if a substrate is maintained at an elevated temperature, it crystallizes. Heat treatment after production is residual amorphous CrOx. It is effective in the semantics which promotes polycrystal-ization further. Since energy is given by heat treatment, a structural change starts and the partial phase transition to the polycrystal

condition that free energy is more low may happen. The Cr+O system of this invention becomes the trigonal Cr<sub>2</sub>O<sub>3</sub>+ metal Cr with heating at the time of such thin film formation, and heating after generation.

[0018] The distorted electrical resistance materials of this invention are made from such a process, and have the following outstanding properties.

[property of this invention distorted electrical resistance materials] gage-factor >20TCR<50 ppm /degree C ] TCS -- < -- this invention sets \*\*500 ppm /further degree C, and even if it mixes other metals below pentatomic %, it does not interfere. However, generally metaled addition reduces a gage factor. So, if metaled addition exceeds pentatomic %, it becomes [ a gage factor ] 20 or less and is not desirable.

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## EXAMPLE

[Example] It is SiO<sub>2</sub> with a thickness of 6 micrometers by the sputtering method on a stainless steel diaphragm substrate with a thickness of 0.2mm. The insulator layer was formed. Furthermore, the distorted resistance film of 0.2-micrometer thickness which makes Cr and O a subject was formed by the vacuum deposition method and the sputtering method on it. Vacuum deposition and the conditions of sputtering are as being shown in Table 1.

[0020]

[Table 1]

表1 真空蒸着法、スパッタリング法による歪抵抗材料の形成条件

	真空蒸着	スパッタリング
到達真空度	$10^{-5} \sim 10^{-7}$ Torr	$10^{-6} \sim 10^{-7}$ Torr
膜形成時の圧力	$10^{-6} \sim 10^{-4}$ Torr	$10^{-1} \sim 10^{-2}$ Torr
膜形成時の基板温度	200℃	150℃
膜形成速度	5 Å/sec	7 Å/sec

[0021] In the case of vacuum deposition, it lengthens to  $10^{-5}$  -  $10^{-7}$ Torr at first, and vacuum evaporation is started after heating a substrate at 200 degrees C. a film formation rate -- 5Å/sec it is. The pressures at the time of film formation were  $10^{-5}$  -  $10^{-6}$ Torr. In the case of sputtering, it lengthened to  $10^{-6}$  -  $10^{-7}$ Torr at first, it ionized argon gas in the plasma by the RF, and formed membranes by the RF sputtering method which strikes Cr target. The pressures at the time of film formation were  $10^{-1}$  -  $10^{-2}$ Torr. Substrate temperature is 150 degrees C or 200 degrees C. Substrate temperature is important. By the approach of this invention, substrate temperature must be 150 degrees C or more. Both may be replaced, although it considers as 200 degrees C in vacuum deposition and being considered as 150 degrees C by sputtering here. Of course, an elevated temperature is more sufficient.

[0022] The formation conditions for every sample, the conditions of heat treatment after formation, and the crystal structure analyzed with the thin film X-ray diffraction method are shown in Table 2.

[0023]

[Table 2]

表2 Crを含む歪抵抗材料の製造条件と結晶構造

試料番号	組成	製法区分	基板温度 (°C)	アニール雰囲気	アニール温度 (°C)	結晶構造 (薄膜X線回折法による解析結果)
1	Cr/7%O	真空蒸着	200	大気	400	bccCr+Cr <sub>2</sub> O <sub>3</sub>
2	Cr/13%O	スパッタ	150	大気	450	bccCr+Cr <sub>2</sub> O <sub>3</sub>
3	Cr/15%O	スパッタ	200	窒素	500	bccCr+Cr <sub>2</sub> O <sub>3</sub>
4	Cr/17%O	スパッタ	150	窒素	450	bccCr+Cr <sub>2</sub> O <sub>3</sub>
5	Cr/3%Mo/12%O	スパッタ	150	大気	500	bccCr+Cr <sub>2</sub> O <sub>3</sub>
6	Cr/1%Mo/7%O	真空蒸着	200	大気	500	bccCr+Cr <sub>2</sub> O <sub>3</sub>
7	Cr/2%Si/5%O	真空蒸着	200	大気	500	bccCr+Cr <sub>2</sub> O <sub>3</sub>
8	Cr/1%Si/12%O	スパッタ	150	大気	450	bccCr+Cr <sub>2</sub> O <sub>3</sub>
9	Cr/4%Al/15%O	スパッタ	150	大気	400	bccCr+Cr <sub>2</sub> O <sub>3</sub>
10	Cr/1%Al/9%O	真空蒸着	200	大気	450	bccCr+Cr <sub>2</sub> O <sub>3</sub>
11	Cr/21%O	スパッタ	常温	なし	なし	アモルファス
12	Cr/12%O	スパッタ	常温	大気	300	bccCrのみ
13	Cr/15%O	スパッタ	常温	大気	500	bccCrのみ
14	Cr/12%O	スパッタ	200	なし	なし	bccCrのみ
15	Cr/3%Mo/12%O	スパッタ	常温	大気	300	bccCrのみ
16	Cr/4%Si/15%O	スパッタ	常温	大気	300	bccCrのみ
17	Cr/1%Si/9%O	真空蒸着	常温	大気	500	bccCrのみ
18	Cr/4%Al/17%O	スパッタ	常温	大気	300	bccCrのみ
19	Cr/3%Al/8%O	真空蒸着	常温	大気	500	bccCrのみ
20	Cr/10%Mo/12%O	スパッタ	200	なし	なし	bccCrのみ
21	Cr/10%Si/17%O	スパッタ	200	なし	なし	bccCrのみ
22	Cr/10%Mo/12%O	スパッタ	常温	なし	なし	アモルファス
23	Cr/10%Si/17%O	スパッタ	常温	なし	なし	アモルファス

1～10実施例、11～23比較例

[0024] In order to confirm the effectiveness of this invention, the example of a comparison from which the formation and the heat treatment conditions other than an example differ is also manufactured and examined. The example of a comparison raised here forms the distorted resistance film by the approach indicated by aforementioned JP,61-256233,A, JP,2-76201,A, and JP,2-152201,A. 1-10 are the examples of this invention. 11-23 are the examples of a comparison. These distorted resistance film was annealed by the inside of atmospheric air, or nitrogen-gas-atmosphere mind, as shown in Table 2. About the example, it has annealed at the temperature of 400 degrees C or more. Many things were tried [ although annealing is carried out when not carrying out annealing about the example of a comparison, ] when it was 400 degrees C or less, and annealing was carried out above 400 degrees C

and annealing was carried out above 400 degrees C.

[0025] Then, the crystal structure was analyzed with the thin film X-ray diffraction method, and the component analysis was further carried out by ESCA. The distorted resistance film concerning an example is bccCr and trigonal Cr<sub>2</sub>O<sub>3</sub>. It was mixture. the example of a comparison consists of Cr and O by the sample 11 with the high concentration of O, and samples 22 and 23 -- perfect -- it is amorphous. The example of a comparison with O concentration lower than it is bccCr and amorphous CrOx. It was mixture. At the example of a comparison, it is amorphous CrOx altogether. It contains. This cannot employ the high gage factor of Cr in accumulating efficiently effectively, but has become a low gage factor.

[0026] In the case of this invention, substrate temperature is made into 150 degrees C or more at the time of formation of the distorted resistance film, and it becomes conditions to anneal above 400 degrees C after formation. An example 1 contains 7% of O other than Cr which is a subject. This is formed with vacuum deposition at the substrate temperature of 200 degrees C. It has annealed at 200 degrees C in atmospheric air. This is bccCr and trigonal Cr<sub>2</sub>O<sub>3</sub>. It was mixture.

[0027] An example 2 contains 13% of O. As for this, substrate temperature is formed of sputtering at 150 degrees C. It has annealed at 450 degrees C in atmospheric air after that. This is also bccCr and trigonal Cr<sub>2</sub>O<sub>3</sub>. It is mixture. An example 3 contains 15% of O. Sputtering is carried out at the substrate temperature of 200 degrees C. It has annealed by 500-degree C nitrogen-gas-atmosphere mind after that. bccCr and trigonal Cr<sub>2</sub>O<sub>3</sub> It becomes.

[0028] An example 4 contains 17% of O. Sputtering is carried out at the substrate temperature of 150 degrees C. It annealed in nitrogen-gas-atmosphere mind at 450 degrees C. This also serves as bccCr from trigonal Cr<sub>2</sub>O<sub>3</sub>. An example 5 contains Mo3% other than 12% of O as the 3rd element. Sputtering is carried out at the substrate temperature of 150 degrees C. It annealed at 500 degrees C among atmospheric air. This is also bccCr and trigonal Cr<sub>2</sub>O<sub>3</sub>. It becomes.

[0029] An example 6 contains 7% of O and 1% of Mo. Vacuum deposition is carried out at the substrate temperature of 200 degrees C. It annealed at 500 degrees C among atmospheric air after that. This is also bccCr and trigonal Cr<sub>2</sub>O<sub>3</sub>. It becomes.

[0030] Vacuum deposition of the example 7 is carried out at . substrate temperature containing 5% of O and 2% of Si of 200 degrees C. It annealed at 500 degrees C among atmospheric air, method \*\* Cr 2O<sub>3</sub> of bccCr+3 it is . An example 8 contains 12% of O and 1% of Si. Sputtering is carried out at the substrate temperature of 150 degrees C. It annealed at 450 degrees C among atmospheric air behind. method \*\* Cr 2O<sub>3</sub> of bccCr+3 it is .

[0031] An example 9 contains 15% of O and 4% of aluminum. Sputtering is carried out at the substrate temperature of 150 degrees C. It annealed at 400 degrees C among atmospheric air. method \*\* Cr 2O<sub>3</sub> of bccCr+3 it is . An example 10 contains 9% of O and 1% of aluminum. Vacuum deposition is carried out at the substrate temperature of 200 degrees C. It annealed at 450 degrees C among atmospheric air. It is method \*\* Cr 2O<sub>3</sub> of bccCr+3.

[0032] Sputtering of the example 11 of a comparison is carried out in ordinary temperature, and it has not carried out annealing again. For this reason, amorphous CrOx in which bccCr is not generated and structure does not become settled It has become. Sputtering of the example 12 of a comparison is carried out in ordinary temperature. It has annealed at 300 degrees C after formation. The remainder is amorphous CrOx although bccCr is formed. It has become. Sputtering also of the example 13 of a comparison is carried out in ordinary temperature. Although annealed at 500 degrees C after that, they are bccCr and amorphous CrOx. It is a mixture.

[0033] The example 14 of a comparison is carrying out and carrying out sputtering of the substrate temperature to 200 degrees C. However, this has not annealed. It is amorphous CrOx too. It remains. As for the examples 15-23 of a comparison, oxygen and elements other than Cr are contained. The examples 15, 20, and 22 of a comparison contain Mo as the 3rd element. The examples 16, 17, 21, and 23 of a comparison contain Si. The examples 18 and 19 of a comparison contain aluminum. If these 3rd metal is included, a gage factor will fall, but shortly after a metal is included, it is not said that it is bad. The examples 5 and 6 of this invention contain Mo. Examples 7 and 8 contain Si. Examples 9 and 10 contain aluminum. Such conditions are the same. However, as for the examples 15-19 of a comparison, other conditions differ from this invention.

[0034] Since substrate temperature is ordinary temperature, the examples 15-19 of a comparison are not applied to the conditions of 150 degrees C or more of this invention. These are amorphous CrOx besides bccCr, although annealing is carried out at the temperature of 300-500 degrees C. It only exists. Trigonal Cr<sub>2</sub>O<sub>3</sub> It is not formed. It is because the substrate temperature at the time of formation was low. The example 20 of a comparison contains 10% of Mo. Sputtering of this is carried out at the substrate temperature of 200 degrees C. However, annealing has not been carried out. It is amorphous CrOx too. It is the mixture of bccCr.

[0035] The example 21 of a comparison contains 10% of Si. At the substrate temperature of 200 degrees C, sputtering is carried out and it forms. Annealing has not been carried out. This is also the mixture of bccCr and amorphous CrOx. The example 22 of a comparison contains 10% of Mo. Sputtering of the substrate is carried out without heating. Moreover, annealing is not carried out. Since it quenches Cr with a substrate, the whole is amorphous CrOx. It becomes.

[0036] The example 23 of a comparison contains 10% of Si. The substrate is not heated. Annealing after formation has not been carried out, either. This is also amorphous CrOx. It has become. If sputtering of the Cr is carried out without heating a substrate from these examples of a comparison, on a substrate, it is amorphous CrOx. Since it is formed and annealing is made behind, bccCr is amorphous CrOx. It is formed in inside and it turns out that it grows up and goes. However, it is amorphous CrOx even if it carries out annealing after formation. It eliminates completely and it turns out that it cannot be made the polycrystal of Cr and oxygen.

[0037] With the vacuum deposition method, the multilayer electrode of Ti/nickel/Au was formed in these distorted resistance film one by one. This is an ohmic contact electrode. The structure of this component is shown in drawing 1. An insulator layer (SiO<sub>2</sub>) 2 is formed on the diaphragm 1 of stainless steel, and there is the distorted resistance film 3 on it further. The multilayer electrode 4 can be formed in the edge of the distorted resistance film 3, and can pass a current now.

Resistance-after gage-factor, temperature-coefficient-of-resistance TCR, sensibility temperature coefficient TCS, thermal-resistance (\*\*, \*\*, \*\*), and distorted durability change was measured about these samples 1-23. Thermal resistance is carrying out the following three measurement. This was shown in Table 3.

[0038]

[Table 3]

表3 各試料の歪抵抗膜の特性

試料番号	ゲージ率	TCR 抵抗温度 係数 (ppm/℃)	TCS 感度温度 係数 (ppm/℃)	高温放 置抵抗 変化 (%)	ヒート サイクル 抵抗 変化 (%)	サーマ ルショ ック抵 抗変化 (%)	歪耐久 後抵抗 変化 (%)
1	21.1	35	-450	-0.6%	<-0.5%	<+0.5%	<-0.5%
2	20.5	-20	330	<+0.5%	<+0.5%	-0.7%	<-0.5%
3	25.3	25	500	<+0.5%	<-0.5%	<-0.5%	+0.7%
4	23.6	-30	-490	+0.6%	<+0.5%	+0.6%	<+0.5%
5	20.0	-47	-480	<+0.5%	-0.7%	-0.5%	<+0.5%
6	21.2	9	-150	<-0.5%	-0.5%	+0.7%	+0.6%
7	20.4	49	-500	<+0.5%	-0.6%	<-0.5%	+0.7%
8	21.0	-35	380	+0.7%	<+0.5%	+0.8%	-0.5%
9	20.3	-20	-350	+0.6%	+0.7%	-0.5%	<-0.5%
10	21.1	28	400	+0.5%	<-0.5%	-0.6%	+0.7%
11	3.0	-15	-520	-35.0%	-27.7%	-21.5%	+7.0%

12	14.5	-650	-2000	-5.2%	+3.7%	+4.0%	+3.7%
13	12.8	-520	-1500	+1.1%	<+0.5%	+2.4%	+5.1%
14	10.3	-730	-1800	+3.5%	-4.3%	-2.7%	+2.2%
15	15.0	-250	-3200	+4.0%	-1.5%	+3.5%	+4.5%
16	9.5	-90	900	-6.6%	-4.7%	-2.6%	+5.0%
17	9.9	88	560	+0.7%	+1.3%	+2.2%	+5.7%
18	6.3	-75	830	-3.5%	+3.9%	-3.3%	+3.0%
19	7.2	95	550	<-0.5%	-1.6%	+1.0%	+4.4%
20	6.0	-180	-1500	+6.3%	-3.8%	-2.8%	+2.0%
21	5.2	-170	-1000	+3.2%	-4.1%	-3.5%	+4.3%
22	4.3	-22	-630	-27 %	-25 %	-22 %	+8.0%
23	3.2	-25	-290	-32 %	-28 %	-29 %	+6.5%

1~10実施例、11~23比較例

[0039]

Resistance change is measured after heating by the approach of each thermal shock of -50 degree-C+120 degree-Cx1000 cycle in the thermo-cycle heat resistance test \*\* liquid phase of -40 degree-C+150 degree-Cx1000 cycle in the elevated-temperature neglect heat resistance test \*\* gaseous phase of heat resistance test \*\* +300-degree-Cx 1000 hours. Of course, the direction with little resistance change is good. I hear that that there is little resistance change has high thermal resistance, and there is.

[0040] Resistance-after distorted durability change is distortion of \*\*2000micro strain 107 It is the thing of the rate of a resistance value change after a \*\*\*\* beam distorted torture test. Also as for this, the smaller one is good. In the example of this invention, 20 or more have all been the gage factor which is an important multiplier. This is what should be mentioned especially. It is difficult to obtain such a high gage factor with metaled thin film distorted electrical resistance materials.

[0041] Moreover, a temperature coefficient of resistance TCR is also 50 ppm/degree C or less in an absolute value, and it turns out that change of resistance by the temperature change is small. The sensibility temperature coefficient TCS is 500 ppm/degree C or less in an absolute value. Thus, this invention can offer the distorted electrical resistance materials which have a high gage factor, low TCR, and TCS. When it anneals at the temperature of 450 degrees C or more especially by the non-oxidizing atmosphere, as for a gage factor, 23 or more things are obtained so that it may see in the examples 3 and 4. They are the distorted electrical resistance materials which were small excellent also in TCR and TCS.

[0042] The ingredient of this invention also has little resistance change after elevated-temperature neglect. It is 0.7% or less in an absolute value. There is also little thermo-cycle resistance change and it is 0.7% or less in an absolute value. . also with the small resistance change after a thermal shock -- this is 0.8% or less. These show that the distorted electrical resistance materials of this invention are excellent in thermal resistance. Moreover, the resistance change after distortion durability is also very small. This is also 0.7% or less. Although it is repeatedly distorted since it is a strain gage, this invention can offer a component with the high dependability from which resistance hardly changes by distortion.

[0043] The substrate heating temperature at the time of thin film formation is 150 degrees C or more. The temperature of annealing after thin film formation is 400 degrees C or more. These give the minimum of heating. The upper limit of heating is based on the property of a substrate. It

must heat-treat at the temperature of extent which does not degrade a substrate. For example, it is SiO<sub>2</sub> on SUS631. If it is the substrate in which the insulator layer was formed, as for the heating temperature at the time of thin film formation, and the heating temperature at the time of annealing, it is desirable that it is 600 degrees C or less. A little metal can also be added in this invention. Although examples 5-10 add Mo, Si, aluminum, etc., these also have 20 or more gage factors. However, since a gage factor will fall if a metal ratio exceeds 5%, it is not desirable. This becomes clear by comparing 12-14, and the example 20 of a comparison - 23 grades of the example of a comparison.

[0044] The gage factor of what was mentioned as an example of a comparison to these is 15 or less. The examples 15, 12, and 13 of a comparison and 14 grades have a comparatively large gage factor. However, these are inferior to thermal resistance and TCR and TCS are large. In an absolute value, TCR of these examples of a comparison is 250-730 ppm/degree C, and is [ / of / of this invention / 50 ppm/degree C or less ] remarkably inferior. Moreover, in the examples 12-15 of these comparisons, TCS is also 520-3200 ppm/degree C, and is inferior with an absolute value compared with the value of less than 500 ppm/degree C of this invention. Although the examples 11, 17-19 of a comparison, and 22 and 23 have TCR and a little small TCS, since the gage factor is low, sensibility is less than the thing of this invention too bad.

[0045] That is, in the example of a comparison, if it is going to stop [ degree C ] TCR in 100 ppm /or less, a gage factor will become less than ten. If it is going to make a gage factor or more into ten, TCR will exceed degree C in 250 ppm /. Moreover, it is difficult to carry out [ degree C ] TCS in 500 ppm /or less in the example of a comparison. Thus, the example of a comparison cannot satisfy the demand imposed on distorted electrical resistance materials about gage factors, and all TCR(s) and TCSes.

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[Translation done.]



多層電極

Au	7
Ni	6
Ti	5

多層電極

Au	7
Ni	6
Ti	5

歪 抵 抗 膜				3
絶 縁 膜				2
ステンレス鋼ダイヤフラム 1				

\* NOTICES \*

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1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. \*\*\*\* shows the word which can not be translated.
3. In the drawings, any words are not translated.

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CLAIMS

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[Claim(s)]

[Claim 1] It is the thin film distorted electrical resistance materials which made chromium and oxygen the subject, and is bcc chromium and trigonal Cr<sub>2</sub>O<sub>3</sub>. Distorted electrical resistance materials characterized by having the crystal structure.

[Claim 2] It is the thin film distorted electrical resistance materials which made chromium and oxygen the subject, the metal below pentatomic % is included, and it is bcc chromium and trigonal Cr<sub>2</sub>O<sub>3</sub>. Distorted electrical resistance materials characterized by having the crystal structure.

[Claim 3] The manufacture approach of the distorted electrical resistance materials which use heating evaporation or chromium as a target, carry out sputtering of the chromium ingredient using a vacuum evaporation system or a sputtering system, and are characterized by forming the thin film which made chromium and oxygen the subject in the substrate heated by 150 degrees C or more, and annealing at the temperature of 400 degrees C or more after that.

[Claim 4] The manufacture approach of the distorted electrical resistance materials which use heating evaporation or chromium as a target, carry out sputtering of the chromium ingredient using a vacuum evaporation system or a sputtering system, and are characterized by forming the thin film which made chromium and oxygen the subject in the substrate heated by 150 degrees C or more, and annealing in a non-oxidizing atmosphere at the temperature of 400 degrees C or more after that.

[Claim 5] Chromium and oxygen are made into a subject on the metal substrate which has an insulator substrate or an insulator, and it is bcc chromium and trigonal Cr<sub>2</sub>O<sub>3</sub>. Thin film distorted sensor characterized by having prepared the thin film distorted electrical resistance materials which have the crystal structure, and preparing the multilayer electrode of Ti/nickel/Au on it further.

[Claim 6] On a stainless steel diaphragm substrate, it is SiO<sub>2</sub>. Thin film distorted sensor characterized by preparing the thin film distorted electrical resistance materials which form an insulator layer, make chromium and oxygen a subject on it further, and have bcc chromium and the crystal structure of trigonal Cr<sub>2</sub>O<sub>3</sub>.

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[Translation done.]